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Treece

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(54) **UNIVERSAL CEMENTING PLUG**

(75) Inventor: **Harold O. Treece**, Duncan, OK (US)

(73) Assignee: **Halliburton Energy Services, Inc.**, Duncan, OK (US)

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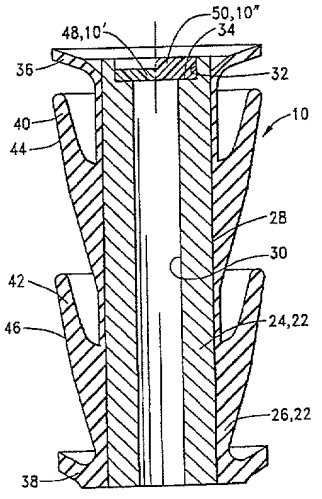
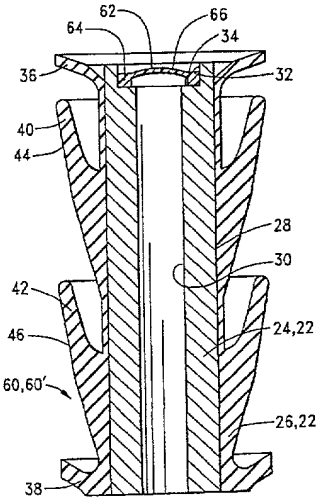
Primary Examiner—Christopher J. Novosad
(74) *Attorney, Agent, or Firm*—Craig W. Roddy; Neal R. Kennedy

(57) **ABSTRACT**

A cementing plug having a universal construction and improved wiping and extended wear characteristics. The cementing plug has a plug subassembly with a body member and an elastomeric jacket on the body member. The body member defines a central opening therethrough with a shoulder therein. To configure the plug as a bottom cementing plug, a shearable insert is positioned on the shoulder, and to configure the plug as a top cementing plug, a non-shearable insert is positioned on the shoulder. The shearable insert is one of a plurality of such inserts designed to shear at correspondingly different shear pressures. In a first embodiment, the shearable insert is a substantially flat disk having a uniform thickness, and in a second embodiment, the shearable insert has an outer ring portion and a relatively thin inner domed portion. Thus, a bottom plug may be pumped down a well casing with cement and a top plug thereabove so that when the bottom plug lands at the bottom of the casing, the shearable insert will shear at the predetermined pressure. The jacket has one or more wiper cups which have a conical surface extending at an acute angle with respect to a longitudinal axis of the plug, thereby providing a substantially large contact area in the well casing to improve wiping efficiency and extend life.

51 Claims, 2 Drawing Sheets





UNIVERSAL CEMENTING PLUG

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to cementing plugs for use in cementing casing in a well, and more particularly, to a universal cementing plug having improved wiping and extended wear and which includes a plurality of interchangeable inserts so that the plug may be selectively used as a top or a bottom plug.

2. Description of the Prior Art

In the process of preparing a well for testing and/or production, a casing is positioned in the well and cemented in place. Typically, at the beginning of the cementing job in rotary-drilled wells, the casing and the wellbore are usually filled with drilling mud. In many areas, to reduce contamination on the interface between the mud and cement a bottom plug is released from a plug container and pumped ahead of the cement slurry. Such plugs have wipers of an elastomeric material thereon to wipe the casing of any accumulated mud film so that the mud is pushed ahead of the bottom plug.

When the bottom plug reaches floating equipment such as a float collar or float shoe at the bottom of the casing string, a fluid pressure differential created across the plug ruptures a rubber diaphragm at the top of the plug and allows the cement slurry to proceed down the casing through the plug and floating equipment and then up an annulus space defined between the casing and the wellbore.

When all of the cement has been mixed and pumped into the casing string, a top cementing plug is released from the plug container. The top plug also has wipers of elastomeric material thereon. The function of the top plug is to follow the cement and wipe any accumulated cement film from the inside of the casing. The top plug is also designed to reduce the possibility of any contamination or channeling of the cement slurry with the drilling mud that is used to displace the cement column down the casing and into the annular space between the casing and the wellbore. The top cementing plug is typically solid in construction, and the design is such that when it reaches the bottom cementing plug at the float collar or float shoe, the top cementing plug causes a shutoff of fluids being pumped into the casing. This causes a normal pressure rise at the surface and notifies the operator that the cementing job is complete.

The landing of the top plug lessens the possibility of any further displacement of the cement slurry and provides a better quality of cement slurry around the bottom of the casing where a good cement bond to the casing is required.

Currently, two different cementing plugs are used in this cementing operation, one for the top and one for the bottom. The bottom plug has a shearable member, such as the rubber diaphragm previously mentioned, which shears when a specific fluid pressure differential is applied thereto. The top plug is substantially solid. Because each plug requires different construction, separate molds must be used for each of the plugs which increase the costs of manufacturing, and also, the two separate plugs must be kept in inventory. The present invention solves this problem by using a single plug subassembly design which has the same general construction whether it is used as a top plug or a bottom plug. A shearable insert is positioned in one plug so that it may be used as a bottom plug. This shearable member is designed to shear at a predetermined differential pressure thereacross. In one embodiment, the shearable member is a flat disc, and in another embodiment, the shearable member has a relatively thin domed portion. Another insert, which is essentially non-shearable at the pressures in which the plugs are utilized, is positioned in another plug so that it can be used as a top plug. By the use of a single plug subassembly, with separate inserts, the cost of molds of the plugs is decreased, and only one plug must be maintained in inventory along with the different inserts.

Another advantage of the present invention is that the shearable member may be interchanged with a plurality of shearable members, including, but not limited to, the two embodiments previously described, designed to shear at any one of a selected number of differential pressures as necessary for different well conditions. This is an improvement over the previous design which had essentially one shear pressure.

With prior art cementing plugs, the wiping efficiency of the wipers on the plugs is affected by pumping rate and wear along the casing surface. The cementing plug of the present invention provides an improved wiper design which offers more surface contact, and as the plug is pumped down the casing, wiping efficiency is increased. As a top cup on the plug wears, the pressure is transferred to a bottom cup which prolongs the surface engagement maintaining the wiping, resulting in extended wear.

SUMMARY OF THE INVENTION

The present invention is a universal cementing plug which may be configured as either a bottom cementing plug or a top cementing plug. The plug may also be described as an improved wiping and/or extended wear plug.

The cementing plug is adapted for use in cementing casing in a well and comprises a body member defining a central opening therethrough, an elastomeric jacket disposed around the body member and having a wiper cup extending therefrom for engaging an inner surface of the casing, and an insert disposed across the central opening in the body member for at least temporary closure thereof. The insert is one of a plurality of interchangeable inserts. These inserts include a shearable insert or disk adapted for shearing and thereby opening the central opening when a predetermined differential pressure is applied across the shearable insert and a substantially non-shearable insert or disk adapted for substantially permanent closure of the central opening. When the cementing plug is configured as a bottom plug, a shearable insert is used, and when the cementing plug is configured as a top plug, a non-shearable insert is used.

Each body member defines a recess adjacent to the central opening with an upwardly facing shoulder therein. When configuring the cementing plug as a bottom plug or a top plug, one of the inserts is disposed on the shoulder.

The invention may also be described as a cementing plug for use in cementing casing in a well, comprising a body member and an elastomeric jacket disposed around the body member with a wiper cup having a substantially conical outer surface thereon extending upwardly and outwardly at an acute angle with respect to a longitudinal axis of the plug. The conical surface deflects into substantially cylindrical, wiping engagement with an inner surface of the casing when the plug is disposed therein. This provides a large wiping surface for improved wiping and increased wear. Preferably, the wiper cup is one of a plurality of such wiper cups. As the upper wiper cup wears, the pressure will be gradually applied to the next lower wiper cup which continues the wiping action. This also provides extended wear life.

Stated in another way, the invention is a cementing plug apparatus for use in cementing casing in a well. The apparatus comprises a first cementing plug and a second cementing plug.

The first cementing plug comprises a first body member defining a first central opening therethrough, a first jacket disposed on the first body member, and a replaceable first disk disposed adjacent to the first body member for temporarily closing the first central opening and subsequently shearing when subjected to a predetermined pressure, thereby opening the first central opening. The first jacket has a wiper cup extending therefrom adapted for wiping engagement with an inner surface of the casing.

The second cementing plug comprises a second body member defining a second central opening therethrough, a second jacket disposed on the second body member, and a replaceable second disk disposed adjacent to the second body member for substantially permanently closing the second central opening. The second jacket has a wiper cup extending therefrom adapted for wiping engagement with an inner surface of the casing.

In the preferred embodiment, the first and second body members are substantially identical, and the first and second jackets are substantially identical. The first and second disks are interchangeable. The first disk is a selected one of a plurality of disks which are shearable at a corresponding plurality of predetermined pressures.

Also in the preferred embodiment, the first body member defines a first shoulder therein, and the second body member defines a second shoulder therein. The first disk is disposed on the first shoulder, and the second disk is disposed on the second shoulder.

Numerous objects and advantages of the invention will become apparent as the following detailed description of the preferred embodiments is read in conjunction with the drawings which illustrate such embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a first embodiment of the universal cementing plug and system of the present invention in use in a wellbore.

FIG. **2** is a perspective illustrating a first embodiment of a shearable insert used in the cementing plug as a bottom plug.

FIG. **3** illustrates in perspective a substantially non-shearable insert for use in the cementing plug as a top plug.

FIG. **4** illustrates a longitudinal cross section of the cementing plug of FIGS. **1–3**.

FIG. **5** shows a second embodiment of the universal cementing plug and system of the present invention in use in a wellbore.

FIG. **6** is a perspective illustrating a second embodiment of a shearable insert used in the cementing plug as a bottom plug.

FIG. **7** is a longitudinal cross section of the second embodiment shearable insert.

FIG. **8** illustrates a longitudinal cross section of the cementing plug as a bottom plug including the second embodiment shearable insert of FIGS. **6** and **7**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and more particularly to FIG. **1**, a first embodiment of the universal cementing plug of the present invention is shown and generally designated by the numeral **10**. Universal cementing plug **10** may also be referred to as an improved wiping and/or extended wear cementing plug. As will be further discussed herein, cementing plug **10** can be configured as a first embodiment bottom plug **10'** or a top plug **10"**. Bottom plug **10'** and top plug **10"** may be referred to together as a first embodiment cementing plug system.

Cementing plug **10** is designed for use in a casing **12** disposed in a wellbore **14**. At the lower end of casing **12** is floating equipment, such as a casing float collar or float shoe **16**, of a kind known in the art, having a valve **18** therein designed to allow cement to be pumped into an annulus **20** between casing **12** and wellbore **14** while preventing backflow.

Referring now to FIGS. **2–3**, the details of first embodiment cementing plug **10** will be discussed. Cementing plug **10** includes a plug subassembly **22** which comprises a body member **24** and a jacket **26** disposed around the body member. Body member **24** is made of any one of a number of drillable materials known in the art, such as aluminum, plastic, wood, etc. Jacket **26** is made of an elastomeric material and is molded onto the outer surface of body member **24**.

Body member **24** has a substantially cylindrical configuration with an outer surface **28** and a central opening, such as a first bore **30**, defined longitudinally therethrough. A larger second bore **32** is defined in the upper end of body member **24** such that an upwardly facing annular shoulder **34** is defined between first bore **30** and second bore **32**. Thus, a recess is formed in the upper end of the central opening.

Jacket **26** has an upper radially outwardly extending lip **36** and a lower radially outwardly extending lip **38**. Between upper lip **36** and lower lip **38** are a pair of upwardly opening cup portions **40** and **42**. Cup portion **40** may be referred to as upper cup **40**, and cup portion **42** may be referred to as lower cup **42**. It will be seen that upper cup **40** and lower cup **42** extend upwardly and radially outwardly. As seen in FIG. **4**, cups **40** and **42** extend at an acute angle with respect to a longitudinal axis of cementing plug **10**, and thus are angled much more sharply with respect to body member **24** than are upper lip **36** and lower lip **38**. Upper cup **40** has an acutely angled conical outer surface **44** which is deflected into substantial wiping engagement with the inner surface of casing **12** as seen in FIG. **1**, and lower cup **42** has a similar acutely angled conical surface **46**.

FIG. **2** illustrates a first embodiment of a shearable insert or disk **48** which is substantially flat and of uniform thickness. FIG. **3** illustrates a substantially solid, non-shearable insert or disk **50** which is also substantially flat. Either of inserts **48** and **50** may be positioned on shoulder **34** in body member **24** of first embodiment cementing plug **10**. Referring to the right side of FIG. **4**, non-shearable insert **50** is shown thus forming a top plug **10"**. In the left side of FIG. **4**, first embodiment shearable insert **48** is shown, thus illustrating a first embodiment bottom plug **10'**.

First embodiment shearable insert **48** is made of a material which is easily sheared or ruptured when a predetermined differential pressure is applied thereacross. One typical material is rubber, but the invention is not intended to be so limited. The thickness of shearable insert **48** may be one of a plurality of available thicknesses so that the shear pressure may be predetermined as conditions dictate.

Non-shearable insert **50** is substantially thicker than shearable insert **48** and is designed to be substantially non-shearable when normal pressures are applied thereacross. Thus, non-shearable insert **50** provides substantially permanent closure of the central opening in the corresponding body member **24**.

Referring now to FIG. **5**, a second embodiment of the uniform cementing plug of the present invention is shown

and generally designated by the numeral **60**. Universal cementing plug **60** may also be referred to as an improved wiping and/or extended-wear cementing plug. As will be further discussed herein, cementing plug **60** can be configured as a second embodiment bottom plug **60'** or the same top plug **10"** as in first embodiment cementing plug **10**. Second embodiment bottom plug **60'** and top plug **10"** may be referred together as a second embodiment cementing plug system.

As with the first embodiment, second embodiment cementing plug **60** is designed for use in casing **12** disposed in wellbore **14**. Again, at the lower end of casing **12** is floating equipment, such as casing float collar or float shoe **16** having valve **18** therein. An annulus **20** is formed between casing **12** and wellbore **14**.

Referring now to FIGS. **6–8**, the details of second embodiment cementing plug **60** will be discussed. Cementing plug **60** includes the same plug subassembly **22** used in first embodiment cementing plug **10**. Therefore, the same reference numerals are used for the components of plug subassembly **22** in FIG. **8** as were used in FIG. **4** for the first embodiment. As with the first embodiment, in the second embodiment, upper lip **40** on jacket **26** has an acutely angled conical outer surface **44** which is deflected into substantial wiping engagement with the inner surface of casing **12** as seen in FIG. **5**, and lower cup **42** has a similar acutely angled conical surface **46**.

FIGS. **6** and **7** illustrate a second embodiment of a shearable insert or member **62**. Shearable insert **62** has an outer ring portion **64** and a relatively thin inner portion **66** which acts as a rupture disk portion. In the preferred embodiment, but not by way of limitation, inner portion **66** has an outwardly convex, curvilinear configuration. Thus, inner portion **66** may also be referred to as a domed portion **66**.

Domed portion **66** is integrally formed with outer ring portion **64** and extends upwardly and inwardly from the ring portion.

Domed portion **66** preferably has a variable thickness including a first thickness X at or near its center and a second thickness Y adjacent to an internal corner **68** formed on the inside between ring portion **64** and domed portion **66**. In the illustrated embodiment, first thickness X is less than second thickness Y. Corner **68** is preferably radiused.

EXAMPLES

Although various materials may be used for shearable insert **62**, a preferred material is 23570 glass-filled plastic from Barlow-Hunt, Inc., of Tulsa, Okla. This material has a working temperature range of room temperature to about 410° F.

The following table illustrates the pressure at which domed portion **66** shears based on different values of X and Y using this material:

X	Y	Shear Pressure
0.100"	0.125"	370 psi
0.125"	0.150"	700 psi
0.131"—0.135"	0.175"	1200 psi

In a preferred embodiment, but not by way of limitation, the height Z of domed portion **66** above ring portion **64** is approximately equal to center thickness X of domed portion **66**.

Second embodiment shearable insert **62** may be positioned on shoulder **34** in body member **24** of plug subassembly **22** to form second embodiment bottom plug **60'**, as seen in FIGS. **5** and **8**.

In second embodiment cementing plug **60**, top plug **10"** used with bottom plug **60'** is identical to that in first embodiment cementing plug **10**.

OPERATION OF THE INVENTION

Referring again to FIGS. **1** and **5**, the operation of cementing plug systems **10** and **60** are shown, respectively. First, a bottom plug **10'** or **60'** is prepared by positioning a shearable insert **48** or **62**, respectively, in body member **24** of a plug subassembly **22**, and a top plug **10"** is similarly formed by positioning a non-shearable insert **50** in body member **24** of another plug subassembly **22**. Bottom plug **10'** or **60'** is dropped into casing **12** in a manner known in the art. Cement **70** is pumped into casing **12** above bottom plug **10'** or **60'**, thus forcing the bottom plug downwardly to displace mud and other fluid in casing volume **72** below bottom plug **10'** or **60'**. This mud is forced outwardly into well annulus **20** after opening of valve **18** in float shoe **16**.

Once the desired amount of cement **70** is pumped into casing **12**, top plug **10"** is dropped into the well, and additional fluid pumped into casing **12** to force top plug **10"** downwardly. The downward movement of top plug **10"**, forces cement **70** downwardly, and thus, bottom plug **10'** or **60'** is also forced downwardly until it lands on top of float shoe **16**. Additional pressure applied above upper plug **10"** will create a pressure differential across shearable insert **48** in bottom plug **10'** or shearable insert **62** in bottom plug **60'** until the insert shears. At this point, further pumping of fluid above top plug **10"** will force cement downwardly through first bore **30** in body member **24** of lower plug **10'** or **60'** and past valve **18** in float shoe **16** so that the cement is pumped into well annulus **20**. Pumping is stopped when top plug **10"** lands on top of bottom plug **10'** or **60'**, at which point all of the cement has been forced into well annulus **20**. Once the cement cures, top plug **10"**, bottom plug **10'** or **60'** and float shoe **16** may be drilled out of casing **12** as desired in a manner known in the art.

The sharply angled configuration of conical surfaces **44** and **46**, respectively, of upper cup **40** and lower cup **42** on jacket **26** of bottom plug **10'** or **60'** and top plug **10"** offers more surface contact with the inside of casing **12** than previous cementing plugs. When bottom plug **10'** or **60'** and top plug **10"** are positioned in casing **12**, conical surfaces **44** and **46** are compressed such that they are in flat, substantially cylindrical contact with the inner surface of the casing. As any of plugs **10'**, **60'** or **10"** move downwardly through casing **12**, the pressure above the plug is first mostly applied to upper cup **40**. As conical surface **44** wears and fluid pressure leaks therepast, the pressure is then applied to lower cup **42** and conical surface **46** thereof. Cementing plug **10** or **60** can be designed with any number of cup portions as well conditions dictate.

Because of the design of new cementing plug **10** or **60**, the operator of the well only has to maintain one plug subassembly **22** in inventory, along with the necessary corresponding number of shearable inserts **48** or **62** and non-shearable inserts **50**. Thus, inventory control is simpler than with prior art plugs. Further, by having a plurality of different shearable plugs **48** or **62**, the operator has the opportunity to select a shear pressure rather than use the single pressure previously available.

It will be seen, therefore, that the cementing plug of the present invention is well adapted to carry out the ends and